

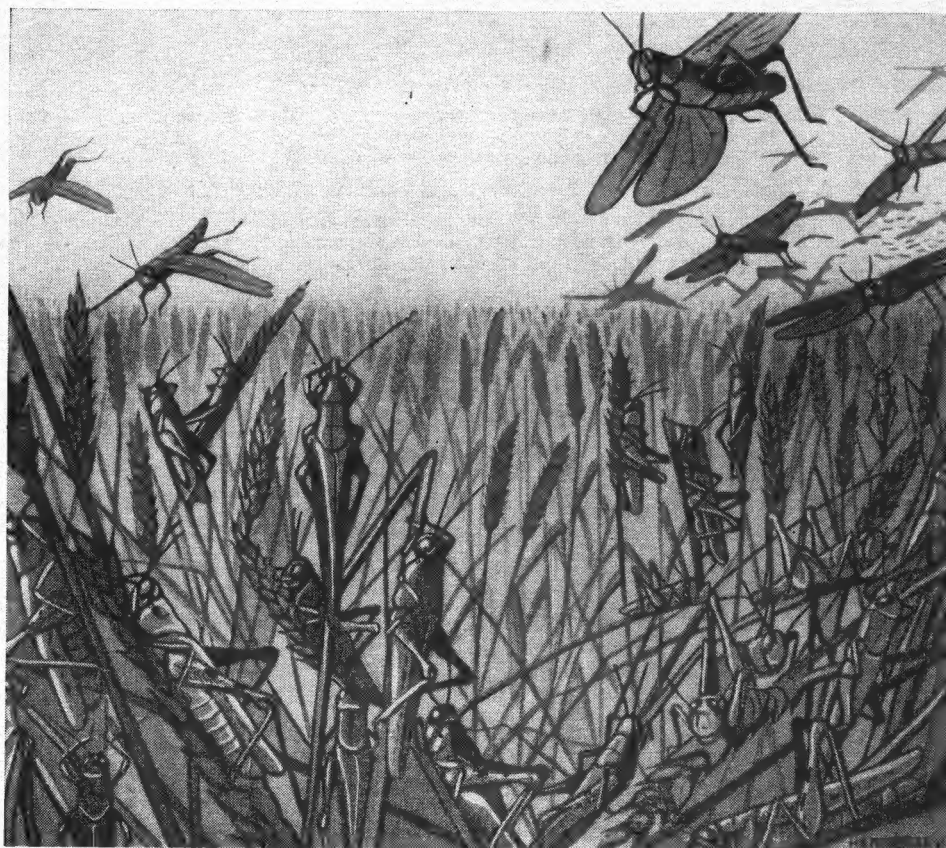
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CRICKET CONTROL IN CANADA EAST OF THE ROCKY MOUNTAINS

By Norman Criddle



DOMINION OF CANADA
DEPARTMENT OF AGRICULTURE

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Summary of Grasshopper Control Measures

Grasshopper outbreaks usually follow, or occur during, abnormally dry weather.

Each female grasshopper lays at least 100 eggs; consequently, a single pair present on a square yard of land in autumn may be responsible for one hundred or more hoppers on the same area during the following spring. Farmers, therefore, are warned to check their grasshopper population in order to be prepared for impending danger. If eggs are present in sufficient numbers to threaten an outbreak efforts should be made to reduce them by (1) deep, well-turned ploughing, (2) shallow fall disking or cultivating.

The first of these methods will prevent a majority of the hoppers making their way to the surface; the second exposes many eggs to adverse atmospheric conditions which destroy them. See page 7.

Watch for the appearance of hoppers in May and early June. When they are present in destructive numbers employ the following control measures:—

(1) Scatter poisoned baits among them according to directions on page 9, making sure before doing so that the temperature is above 68° F. and not over 90° F. The success in applying poisoned baits depends upon the temperature. On no account should baits be spread on cold or cloudy days.

(2) Check the advance of the hoppers from adjacent areas by ploughing guard strips. Force the insects to the centres of stubble fields by ploughing inwardly and poison the central strips. See page 8.

(3) Scatter straw for the newly hatched hoppers to sleep in and burn this at night.

(4) Watch for the invasion of winter wheat or rye and poison the grasshoppers found attacking it.

Grasshoppers do not deposit eggs in clean summer-fallow or in newly ploughed land but may do so among winter wheat or rye. Their main egg beds will be in stubble fields, deserted farms, roadsides, and over-grazed pastures. All these places should be watched and measures taken to destroy the eggs when abundant.

In many localities, particularly on the prairies, grasshoppers fly long distances, consequently farms free from them in the spring may later become heavily infested. Watch should be kept for such invasions and steps taken to combat them when they occur.

When in doubt regarding the control of grasshoppers write to the nearest Entomological Laboratory or Agricultural College for advice. Officers at such stations are always pleased to be of assistance.

Grasshopper Control in Canada East of the Rocky Mountains

By NORMAN CRIDDLE, *Entomological Laboratory, Treesbank, Manitoba*

PART I

INTRODUCTION

From the year 1800, when Alexander Henry in his journal recorded grasshoppers piled up several inches deep along the shores of lake Winnipeg, to the present day, outbreaks of grasshoppers in Canada have been of almost periodic occurrence. There were times, in the early days, when the Prairie Provinces were overrun by countless numbers of these insects. These times were followed by lesser outbreaks and by years of rarity; but as surely as these fluctuations took place in the past so may we expect similar ones to occur in the future. There will be periods when the farmer will find his powers taxed to the utmost in order to save his crops from these voracious insects; there will be others of longer duration when he will be wholly free of them.

In Eastern Canada grasshopper outbreaks are usually less extensive and severe than they are in the Prairie Provinces, but, in spite of this, the insects, in past years, have appeared in large numbers both in Ontario and Quebec; nor have the other provinces been wholly free from their depredations. Apart from the well known injury to field and garden crops, grasshoppers, in the fruit belts, have been known to turn their attention to fruit trees and there were occasions when the insects did serious damage to young apple trees by gnawing off the bark. While, however, the injury in Eastern Canada may be more diversified, the remedial measures are similar in all sections of the country. This, in particular, applies to the use of poisoned baits which in effectiveness far outweigh any other method of grasshopper control.

Since grasshopper control in British Columbia presents problems not encountered in other parts of Canada and as these have already been dealt with in Bulletin No. 39, new series, "Grasshoppers of British Columbia", Department of Agriculture, Ottawa, (Entomological Bulletin No. 26), they will not be referred to further in this publication.

The term "hopper" is used to designate the immature insect and to separate it from the mature, winged grasshopper. We thus have the hopper stage and the winged stage. The term "hopper" does not apply to, and should not be used for, the adult grasshopper.

KINDS OF GRASSHOPPERS INVOLVED IN OUTBREAKS

Any kind of grasshopper may become obnoxious providing it is present in sufficient numbers, but as a rule those forms which do so are comparatively few and they usually comprise only four or five species, these being, the lesser migratory grasshopper (*Melanoplus mexicanus* Saus.), the red-legged grasshopper (*Melanoplus femur-rubrum* DeG.), the two-striped grasshopper (*Melanoplus bivittatus* Say), and the clear-winged or roadside grasshopper (*Camnula pellucida* Scud.). In addition to these about a dozen other kinds usually occur in more or less injurious numbers; these are, Packard's grasshopper (*Melanoplus*

packardi Scud.), the narrow-winged grasshopper (*Melanoplus angustipennis* Dodge), Bruner's grasshopper (*Melanoplus bruneri* Scud.), the minor grasshopper (*Melanoplus confusus* Scud.) and the Carolina grasshopper (*Dissostiera carolina* L.). Most of these grasshoppers have very similar habits and it will not, therefore, be necessary to treat them separately.

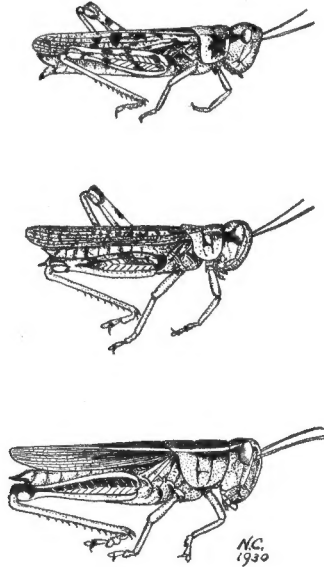


FIG. 1.—Adult grasshoppers. Upper figure, clear-winged grasshopper; middle figure, lesser migratory grasshopper; lower figure two-striped grasshopper. All natural size. (Original)

HABITS OF GRASSHOPPERS

All the different grasshoppers with which we are here concerned hatch from eggs deposited in the ground during the previous year. Their appearance in spring depends upon the weather, but under average conditions some of them can be expected to emerge early in May, while others will not do so until well into June. Warm weather hastens their emergence and development; cold weather retards them.

As the newly hatched grasshopper, or hopper as it is termed, makes its way to the surface, it undergoes what is known as the natal moult and leaves near its exit hole a curled up, white skin. Before this, it was a helpless object unable even to stand; immediately afterwards it presents all the appearance of a miniature, wingless grasshopper excepting that it is pale in colour and requires an hour or more to become fully coloured.

The hopper now seeks a sunny, sheltered, situation where it basks in the sun and undergoes that further developing process necessary to assume its place with its hungry companions. Feeding does not usually take place until the following day and to begin with the amount of food taken is small. Two activities now dominate the insect's life, namely, the act of feeding and that of sunning itself. In the morning, as the sun begins to warm the atmosphere, the hopper leaves the shelter which it has occupied overnight and joins its associates in some sunny spot where they all huddle together in a mass, governed in size by the

numbers present in the vicinity. Here they remain until the temperature rises to about 65° F. in the shade, when they begin to scatter in search of food. The height of the feeding activity, however, is not reached until the temperature attains approximately 78° F.

With feeding comes growth and as the hopper's skin does not grow with the insect it becomes necessary to cast it off through a process known as moulting. This is done by the hopper hanging upside down attached by its legs to some support and slowly wriggling out of its old coat. All our most injurious grasshoppers, on an average, moult five times in the course of their development and these stages in growth can be recognized by certain modifications in structure, among the most important of which are the increased number of segments in the antennae and the development of the wing-pads. Thus, in the antennae, with some variation, the segments increase from 13 to 17, 20, 22 and 24, while in the last two immature stages after the second moult the wing pads are upturned. In the first of these they meet over the back near their tips; in the second they lie along the back in an almost horizontal position. After this stage the hopper undergoes one more moult when it acquires fully developed wings and becomes an adult grasshopper. With maturity the insect begins to assume new interests. True, it is still a voracious eater but in addition to this it has now the responsibility of providing for future generations of its kind, and mating, egg-laying and migrating are added to the habit of feeding. The adult state is usually acquired towards the middle of July, although the date varies in the different species and depends upon the time of hatching. Under ordinary weather conditions about 40 days are necessary for development from hatching to the adult state and about three weeks more are spent before egg-laying begins.

Egg-laying.—While the process of egg-laying is similar in all our common grasshoppers, the situations chosen for the placing of the eggs are often quite different, and on this account it is necessary to know what kind of grasshopper we are dealing with. As a general rule it may be stated that the clear-winged grasshopper deposits its eggs in sod land, such as grassy roadsides, pastures and grass fields; rarely, if ever, in clean stubble fields. All the other kinds, with which we are dealing, place their eggs in bare spots but especially in stubble land and

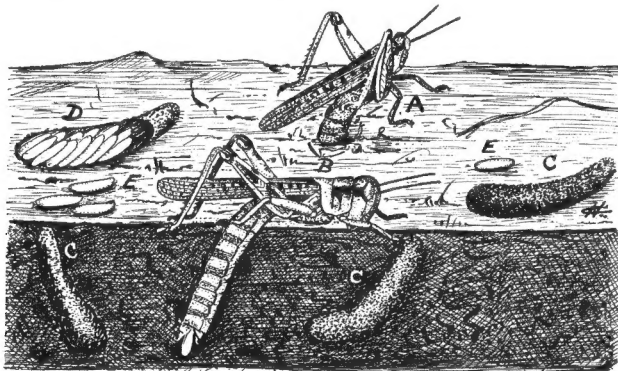


FIG. 2.—Lesser migratory grasshopper. (A) Drilling preparatory to egg-laying; (B) egg-laying; (C) egg-sacs; (D) egg-sac broken open to show eggs within; (E) individual eggs. All natural size. (Original)

old abandoned fields. Those of this last group never lay eggs in clumps of grasses although they may be laid around them in openings free of vegetation. A field in which the grass is sparse or scattered as well as an overgrazed pasture may harbour many eggs. Recently ploughed land on the other hand is never utilized for egg-laying, nor is clean summer-fallow, but a corn field or potato patch may sometimes be rather heavily infested with eggs.

The eggs are laid in the soil enclosed in an elongate sac or pod the neck of which reaches very close to the surface. The number of eggs in each sac varies from about 10 to 34 in the smaller kinds, such as the lesser migratory and clear-winged grasshopper, while in the two-striped grasshopper the number may exceed one hundred. Several sacs of eggs are deposited in the course of a season, the actual number depending somewhat upon the weather. The average number of eggs laid by the lesser migratory, red-legged and clear-winged grasshoppers is about 150; the two-striped and Carolina grasshoppers on the other hand each lay about 200 eggs.

The egg sacs in autumn are usually closely formed around the eggs but as the eggs swell with the development of the hoppers within them, they force the covering asunder so that by spring these sacs are often much broken up.

In depositing eggs, the female grasshopper works her abdomen into the soil to its full length; she may test several places before finding one that suits her but having eventually become satisfied she deposits her clutch of eggs, covers the hole, either with her abdomen or hind legs, and then hops away. Later in the season she lays another lot of eggs, and still later a third, fourth or fifth, until, if the season is favourable, she exhausts her capacity for reproduction and dies of old age.

Migration.—The migration of adult grasshoppers, particularly in Western Canada may have an important bearing on the infestation of the following year and on this account it should be observed with some care. Flights are, also, apt to take place from one area to another, and fields previously free may in this way become heavily infested. These migrations are by no means always made in search of food. We have observed grasshoppers rise in the midst of plenty and move to pastures far less green. Indeed, the flights early in the season are of almost daily occurrence and they may continue back and forth for days, depending wholly upon the force and direction of the wind. Some of these flights are quite low, others so high that the insects can only be seen with the aid of field glasses.

As the season advances and egg-laying time arrives, migrations become less frequent, and then, when grasshoppers become abundant in a locality, it may be assumed that they will lay their eggs in the vicinity. Such places should be carefully noted and later in the season a search made for the eggs. In this way the farmer may become warned of impending danger and make preparations to guard against it. There is a good deal in common, late in the season, between migration and egg-laying due to the fact that the grasshoppers are then seeking suitable egg beds. This activity is particularly noticeable in the clear-winged grasshopper, which, at the time of egg-laying, deserts the cultivated fields and congregates on some particular piece of sod land. First the males arrive and these are followed shortly afterwards by the females. If the insects are abundant the grass in the vicinity is soon eaten down close to the ground and the area then becomes barren and unattractive to look at. Its appearance, however, is an unmistakable sign, even after the grasshoppers have died, that it is an egg bed. On the prairies the closely growing western couch grass, *Agropyron Smithii* Rydb., provides particularly attractive sites, while in other places blue grass or any of the bunch grasses may be chosen.

Another interesting fact about the clear-winged grasshopper is that it shows a marked tendency to select alternate egg beds and on this account eggs are rarely found for two years in succession exactly in the same place. This habit has also been noted in the lesser migratory grasshopper but it is much less marked in this species due doubtless to the less restricted egg-laying habits of that insect.

The migration of grasshoppers in their immature stages appears to be more for the purpose of discovering new feeding grounds than for any other reason.

This, however, is not always the case, as there are occasions when extensive movements take place during which all the hoppers over a considerable area travel in the same direction on fields by no means devoid of suitable food. These migrations in which food is no object have usually been observed in the later stages of development and they are largely confined to the lesser migratory grasshopper and a few closely allied species.

LATE AUTUMN AND EARLY SPRING GRASSHOPPERS

There are several kinds of grasshoppers which hatch from eggs in late summer and which winter in a partly grown form. These may be found as soon as the thawing of the snow exposes the ground. They can be recognized at this time by their large size and by noting that the wing pads are turned upwards. Indeed, most of these grasshoppers will be flying before the really important ones have hatched. The commonest of these early species are the spring clear-winged grasshopper (*Psoloessa delicatula* Scud.), the northern spring grasshopper (*Arphia frigida* Scud.), and the coral-legged grasshopper (*Xanthippus corallipes latefasciatus* Scud.). These are the grasshoppers which usually give rise to the erroneous reports that eggs of the more injurious species are hatching in the autumn, or that they have done so abnormally early in the spring. The spring clear-winged grasshopper in particular has frequently been mistaken for the common clear-winged grasshopper which rarely begins to hatch before the middle of May. Occasionally these insects may do a certain amount of damage to fall wheat or rye but as a rule their activities are insignificant.

CONTROL

Grasshopper control to a certain extent depends upon the kind of grasshopper involved. This in particular relates to egg destruction and early hopper invasions from adjacent areas. If the insect concerned is the clear-winged grasshopper then, to begin with, only the nearby grass lands need be watched and attended to, but if it be the lesser migratory grasshopper then particular care must be given to the stubble fields, deserted farms and to a lesser degree the grasslands as well. One of the first considerations, therefore, in early grasshopper control is to recognize the kind of grasshopper involved. While the methods employed in destroying these insects depend somewhat upon the species present and the conditions under which the outbreak is taking place, they may in a broad sense be outlined as follows:—

EGG CONTROL

Ploughing.—Land known to be infested with grasshopper eggs should be ploughed to a depth of not less than six inches and the furrow turned so that it falls flat. If this advice is followed a large percentage of the hatching hoppers will fail to make their way to the surface, but if the furrow is merely turned on edge then a large number will escape. In any case it is advisable to harrow the land after ploughing and, if the work is done in the spring, the ploughing should be packed.

Our experiments show that the newly hatched hoppers readily make their way through shallow or loosely packed ploughing and that a certain number will do so even after the work has been done in the most approved fashion. Ploughing is not, therefore, a definite means of clearing land of grasshoppers but it can be made an important aid to keeping the insects within bounds.

Cultivating.—Cultivating with a disc-harrow or cultivator is sometimes very effective in destroying grasshopper eggs but its effectiveness depends a good deal upon the prevailing weather conditions. In any event the cultivation should be done as early as possible in the autumn, or as soon as a majority of the eggs

have been laid. This, on an average, will be about the middle of September. The idea is to expose the eggs to the vicissitudes of weather, especially to the sun which dries them up. Spring cultivation is of little or no value. In cultivating it should be remembered that grasshopper eggs at their lowest depth in the soil are not more than an inch below the surface and that shallow cultivation is all that is required to expose them.

PRECAUTIONS TO BE TAKEN

A knowledge that grasshoppers are likely to be troublesome in certain areas enables us to provide for their reception or take measures to counteract their threatened activities. Among such precautionary measures the following may be found useful:—

Guard strips.—When a field of grain exists next to one known to be infested by young hoppers it will often be an advantage to plough a strip between the two to act as a barrier. This will retard the advance of the insects for several days, and if a deep, wide furrow is ploughed on the side from which the insects are advancing, this will temporarily entrap them and provide a convenient situation for killing them with poisoned bait.

Another method that can be recommended is to plough infested fields from the outside and thus gradually force the hoppers to the centre, or to central strips. Then, when the remaining unploughed areas are about 20 feet wide, poisoned bait should be scattered over them. It is advisable to avoid making these strips too narrow during the heat of the day but rather to do the final ploughing in cool weather or late in the afternoon. Moreover, the strips should be poisoned over immediately the hoppers show marked activities, that is when the temperature reaches about 68° F. in the shade. A delay may result in their leaving the unploughed strips and invading the nearby fields.

Time of sowing.—Early sown grain, due to its more advanced growth is better able to withstand grasshopper attack than is late sown grain.

Spring ploughing.—Care should be taken to avoid sowing crops on spring ploughing known to be impregnated with grasshopper eggs. There are no crops immune from these insects and when they hatch all over a field the difficulty and cost of saving the crop is very great.

Burning.—Young hoppers require some sort of shelter in which to pass the night. Rough ploughing will provide this, as will also weeds. If there are no shelters in the grain field the insects will retire to the protective margins of the field for the night where they collect among the weeds or grass but if similar shelters are available in the fields then there will be no check to their advance. It is largely due to the necessity for shelter, to begin with, that the advance into a field is so uneven. The habit of seeking shelter suggests the spreading of small quantities of straw near the places where the insects are feeding, among which they will gather towards evening and remain until next morning. The straw should be burned at night, preferably when a breeze is blowing. Road-sides can, also, be burned over with profit when the hoppers first emerge and before they invade the adjacent grain fields.

Infestation of autumn sown crops.—Winter wheat and rye are apt to be severely attacked by adult grasshoppers and it becomes necessary, therefore, to watch for the invasions of these crops and to destroy the insects when this occurs. This can be accomplished by the application of poisoned baits. Another danger to such crops is incurred when the grasshoppers lay eggs among them from which hoppers emerge and attack them the following spring. On this account the poisoning of adults in autumn becomes additionally important.

DESTRUCTION OF THE HOPPERS AND ADULTS

Poisoned baits.—Of all the methods employed in controlling grasshoppers, poisoned baits in their effectiveness stand out alone. A number of these have been devised and several are recommended in different parts of North America, but in recent years we have discovered that the time of applying baits is of more importance than are the exact ingredients with which they are made and that success or failure in their application is very largely a matter of temperature.

A poisoned bait which was used extensively in Manitoba during the 1919-23 outbreaks of grasshoppers is prepared as follows:—

Bran..	50 pounds
Sawdust..	50 "
White arsenic or Paris green..	4 "
Salt..	2 "
Water, about..	10 gallons

The first four ingredients are mixed together and the water afterwards added. All are then stirred until thoroughly mixed. The bait is then ready for use. It should be sufficiently dry to crumble in the hands, and on this account the amount of water used depends on the moistness of the sawdust. This bait can be made somewhat more attractive by the addition of one quart of cheap molasses or by adding five ounces of amyl acetate. Either one may be added, not both. These extras are of most value under adverse weather conditions such as an overcast sky or a low temperature when some extra attraction is needed to induce the grasshoppers to eat. Salt, while a distinct appetizer and more or less an attractant over most of the country, loses its value when the water used for mixing baits is salty or alkaline and under these circumstances one of the two ingredients mentioned above might be used to advantage instead. Water has a distinct attractiveness to the insects especially under hot, dry weather conditions, and on this account the importance of applying the bait when it is moist cannot be too strongly emphasized. It should be recognized that grasshoppers drink as well as eat and that they do not relish dry food. We recommend white arsenic for extensive campaigns because of its cheapness and accessibility in large quantities but of late another poison has come into use which may eventually prove more economical than arsenic. This poison is sodium arsenite. It is put up in liquid form which makes bait mixing easier and obviates the danger from inhaling a poisoned dust. It also kills more quickly. Sodium arsenite may be substituted for white arsenic and used at the strength of one pint to forty pounds of the carrier such as bran or sawdust. In local grasshopper outbreaks where other poisons are not readily procurable calcium arsenate may be used.

Another substance which gives promise of improving our grasshopper baits is known as "dry brewers' grains". This is the barley refuse left over from brewing. The material appears to be distinctly attractive to the insects in all stages of development. It was first tested at our Lethbridge Laboratory some years ago but was discarded at the time because of its comparatively high cost. The price in late years has been reduced and some recent experiments by Professor G. J. Spencer and Mr. E. R. Buckell in British Columbia indicate that this material may now be utilized to marked advantage as a substitute for, or mixed with, bran and sawdust.

Sawdust is not eaten as readily by the grasshoppers as is bran but this disadvantage is offset by its cheapness and its value as an aid to mixing. It also helps to insure an even spread and reduces the tendency to waste the bran by scattering it too thickly. When sawdust is not available bran can be used alone or the former may be used in smaller proportions.

A bait which gained considerable notoriety in Manitoba during the grasshopper campaign of 1900-03 and has since been used with success in other parts of the world, is known as the Criddle mixture. This bait is prepared in the following manner:—

Horse droppings..	25 pounds
White arsenic or Paris green..	1 pound
Salt..	$\frac{1}{2}$ "
Water to moisten.	

As in other baits the water is added after the first three ingredients have been thoroughly mixed. This bait is not practical at central mixing stations but it has an important place for individual farmers who reside some distance from such stations. Its chief advantage lies in its cheapness and it is in other respects, as well, a thoroughly efficient bait.

As we have stated above, the success of poisoned bait applications depends to a marked degree upon weather conditions, but especially upon temperature. The day should be bright but above all else the temperature when the bait is put out should not be less than 68° F. in the shade with indications that it will rise still higher within the next hour. The temperature at which grasshoppers feed most freely is between 75° F. and 85° F., they stop eating when it rises above 95° F. or when it falls below 65° F. The secret of success in poisoning grasshoppers is, therefore, to spread the bait when the appetite of the insects is keenest; this as intimated above, is when the temperature reaches approximately 75° F. in the shade. By applying the bait at this time we can be sure of its being fresh and moist in which condition it is most appreciated by the grasshoppers, the result being a maximum kill for the expense and labour involved.

Care should be exercised in spreading poisoned bait so as to scatter it finely; 25 pounds are sufficient to cover approximately four acres. It should be placed amongst the grasshoppers in order that they may begin to eat it as soon as it reaches the ground. It is, also, necessary in spreading poisoned bait to use some sort of vehicle to carry it in order that one may get over the ground quickly. Anything from a horse and a rig to a motor car may be utilized for this purpose, and the bait can be spread broadcast either by hand, with the aid of some convenient article such as a trowel, or even by mechanical spreaders. The last named as yet, however, have not proved very successful. The main necessity in spreading bait is to scatter it finely and place it where it can be immediately eaten by the grasshoppers.

Grasshoppers are more easily reached before they attain the winged stage but they will eat poisoned bait at any stage of their development, and in reality they are probably more readily poisoned when large than when small due to the proportionally greater amount of poisoned bait eaten.

The danger of leaving mixing utensils where live stock can reach them should be carefully guarded against. This also applies to bags in which bait is transported. Poisoning of live stock is also possible when poisoned bait is put out in lumps instead of being spread finely. If cattle are well supplied with salt they will be less apt to be attracted to bait in which salt is present. We would, also, emphasize the danger, in mixing baits, of getting the poison dust into the mouth or nose. This can be avoided by tying a cloth over these organs or by wearing a mask.

Mixing stations at central points are essential in the case of extensive grasshopper outbreaks and machine mixing is quicker and more efficient than hand mixing. Several types of mixing machines have been devised and some of them patented. These are usually cylindrical in shape and consist of a fixed or revolving drum. In the former type a few round iron bars revolve inside the drum; in the latter the bars are fixed. The machines are run by small gas engines.

The use of hopperdozers and other mechanical contrivances have all been superseded by the more practical and efficient poisoned baits; the same can be said of poison gases, oil sprays and burners. There is always a tendency during

grasshopper epidemics to resort to some supposedly new and untried method of control, or for some inventive member of the community to demonstrate his mechanical ingenuity. Judging from past experience, however, such innovations are rarely, if ever, of any practical value and it seems wisest to confine our energies to the methods which have proved to be efficient and leave to experts the problem of attempting to devise something better.

ORGANIZATION

While local outbreaks of grasshoppers can readily be controlled by the farmers concerned, severe ones require efficient organization and central purchasing agencies for the procuring of supplies. On this account supervision is necessary and it does not seem possible, at the present time, to do without some form of municipal or governmental aid. This seems desirable in order to ensure having the necessary supplies on hand and to provide for uniformity of action. Without this assistance much loss must inevitably occur.

FIELD CRICKETS

The common, black, field cricket (*Gryllus assimilis* Fab.) is present over most of the settled parts of Canada. As a rule it does little harm but occasionally it becomes very abundant and at such time serious damage has been caused by the insect to the seed heads of flax.

The eggs of this cricket are deposited singly in the ground by aid of a long, spear-like ovipositor; they are small, cylindrical, polished objects. From these the tiny crickets hatch in springtime and after moulting six or seven times become mature. It is in their adult state that they injure flax and, more rarely, other plants.

Damage by field crickets appears always to be worst during dry weather and it is suspected that the insects attack the flax heads partly for the purpose of obtaining moisture. They can be destroyed by a poisoned bait made of bran, white arsenic and water, in the same proportions as the grasshopper bait. This should be scattered over the infested area late in the afternoon, the crickets being evening and night feeders.

Crickets have also a habit of congregating in sheaves and grain stooks where, in company with grasshoppers, they occasionally do considerable mischief by gnawing through the bands of twine. Most brands of twine are now treated with an insect repellent but as these do not always provide the necessary protection, home treatment sometimes becomes desirable. Experiments carried out by us some years ago indicate that the desired immunity may be obtained by thoroughly saturating the twine with wood smoke. This can be done in a smoke house or large tight box in a similar way to that employed in smoking hams.

FORECASTING OR ANTICIPATING GRASSHOPPER OUTBREAKS

While all our destructive grasshoppers are natives of Canada this does not prevent those breeding in adjacent territory from invading our country and because of this fact it is not always possible to accurately forecast when, or where, outbreaks will take place. Since, however, all the most severe outbreaks result from eggs laid in the neighbourhood during the previous year, a careful watch for egg-laying adults should provide ample warning of impending danger.

As a general principle we would suggest that the presence of grasshoppers in excess of one to a square yard should be looked upon with apprehension and that under such circumstances the nearest entomologist be asked for advice.

NATURAL CONTROL

On consulting the weather records we find that all grasshopper outbreaks in recent times were preceded by abnormally dry weather, but while dryness started the insects on their upward trend it was by no means essential to their

further increase and as a matter of fact they often continue to multiply with actually more than an average precipitation. While, however, grasshopper outbreaks often owe their inception to dry weather it is interesting to note that their decline may actually occur under similar conditions. This apparent anomaly is explained by the fact that natural enemies must, of necessity, be scarce at the beginning of an insect outbreak but that they ultimately increase and subdue it even though climatic conditions are favourable to increase. We, also, have to recollect that abundance means close contact and that close contact is one of the most important aids in the spread of disease.

Meteorological factors, but especially rainfall and temperature, play an important part in governing the number of eggs laid by grasshoppers, and prolonged cold, wet spells, not only destroy a number of the insects but many more are weakened and thus made more subject to diseases.

Once in a while some very abnormal form of weather will destroy the newly hatched hoppers in enormous numbers, but such occurrences are rare. They are usually brought about by an abnormally early, warm, spring which causes the hoppers to hatch before the usual time. Such early warm conditions when followed by cold, wet ones provide a combination of adverse conditions which the insects are unable to withstand. Such catastrophies to the grasshoppers are rare and we have known the hoppers to survive a snowstorm accompanied by freezing temperature without harm.

The natural enemies of grasshoppers are many and these in time invariably reduce their hosts to comparative harmlessness. A very large proportion of our bird population feed more or less regularly upon grasshoppers and some of these, such as sharp-tailed grouse, actually owe their increase or decrease very largely to the comparative numbers of grasshoppers present. Among the most important bird enemies of grasshoppers, gulls hold a foremost place, and there have been times when these beautiful birds played an important part in local grasshopper suppression. While, however, birds are our useful allies in this work they cannot be relied upon to overcome severe outbreaks, and when these take place we have to look to smaller but more reliable allies. These we discover in certain insects such as bee-flies, flesh-flies, tachinid flies, blister beetles, and ground beetles. Many of these insects are usually present but as a rule one or two species eventually outrank the others in importance and thus ultimately reduce the grasshopper population to insignificance.

In our experience two insects have been especially valuable in reducing grasshopper outbreaks these are, Kelly's flesh-fly (*Sarcophaga kellyi* Ald.) and the common bee-fly (*Systoechus vulgaris* Loew). The former attacks the living grasshoppers upon which it deposits its maggots; the latter destroys the egg masses, the curiously wrinkled white maggot often found among the eggs being the immature form of this fly. Other insect enemies of grasshoppers are Hunter's flesh-fly (*Sarcophaga hunteri* Ald.), the pale bee-fly (*Systoechus solitus* Walk.), several blister beetles, including the pale blister beetle (*Epicauta sericans* Say), the black blister beetle (*E. pennsylvanica* DeG.), the ash-grey blister beetle (*Microbasis unicolor* Kby.), the prairie blister beetle (*M. subglabra* Fall), small blue blister beetle (*Lytta sphaericollis* Say), the stout ground beetle (*Percosia obesa* Say) and several others.

The red grasshopper mite found on the wings of grasshoppers is often very abundant but while it undoubtedly performs a useful part in weakening its hosts it appears rarely to kill them and we suspect that its importance has been over-rated. It is also an enemy of grasshopper eggs.

Fungous and bacterial diseases are of marked value in destroying grasshoppers. Their spread, however, depends largely upon weather conditions and on this account they are not so dependable as are parasites. Nevertheless, diseases frequently play a very important part in grasshopper suppression.

PART II

Technical (for use of leaders in control campaigns)

In fighting grasshoppers it is important to recognize the different species involved, not only in the adult stage but, also, in the various immature forms. This will become apparent when it is realized that the insects concerned have occasionally very dissimilar habits which necessitate different methods in combatting them. It is to assist in making these determinations that the following descriptions have been prepared. They are of necessity somewhat technical and their use will be largely confined to the officer in charge of operations. He will be able to interpret them and pass on the information to those who are interested.

KEY TO FIRST STAGE HOPPERS

In this key an attempt is made to point out the most striking differences between the nymphs of our common grasshopper pests. It should be used in conjunction with the figures.

It must not be supposed that this key separates the species included from all others that may be met with, but it does so from all *abundant* species and it should, therefore, be used for masses rather than individuals present in comparatively small numbers. A first stage hopper may be recognized as such by its 13 segmented antennae; in the next stage it has 17 segments and in the third 20. In the fourth stage the wing-pads are upturned and meet near their tips, and in the final nymphal stage they are almost horizontal.

For information on later stages, or instars, the notes under individual species should be consulted. In every instance the descriptions which follow refer to living, or freshly killed, examples.

1. Head with distinct foveolae, or pits, in front of eyes; colour contrastingly black and white. *Camnula pellucida*
Head without foveolae; colours less contrasting (*Melanoplus*) 2
2. Brown, green or greyish, without white markings. 3
Obscurely black and brown with white markings. 4
3. Hind femora obscurely spotted and with a median longitudinal basal black streak. *M. bivittatus*
Hind femora more plainly spotted, without a basal black streak. *M. packardi*
4. Hind femora with large black and white bands on upper flanges. 5
Hind femora with upper flanges wholly pale. *M. femur-rubrum*
5. Head with a curved white band below, eyes extending narrowly across lateral lobes of pronotum. *M. confusus*
Head without a curved white band. *M. mexicanus*

KEY TO THE IDENTITY OF ADULT GRASSHOPPERS

In their adult state our more injurious grasshoppers may be identified by means of the following key:—

1. Head with foveolae above eyes, outer wings marked with dark spots and broken bars. *Camnula pellucida*
Head without foveolae (*Melanoplus*) 2
2. Wings spotted in median area. 3
Wings unspotted. 5
3. Palpi pale tipped or obscurely suffused at tip with dark shades. *M. confusus*
Palpi broadly dark tipped. 4
4. Hind femora usually obscurely banded on outer face as well as on outer, upper flange. *M. mexicanus*
Hind femora suffused with black on outer face, never banded, upper, outer flange nearly always pale. *M. femur-rubrum*
5. Hind femora with a black stripe. *M. bivittatus*
Hind femora without a black stripe. *M. packardi*

NOTES ON INDIVIDUAL SPECIES

Camnula pellucida Scud., clear-winged grasshopper.—Structurally this species can be separated from those of the genus *Melanoplus* by the foveolae above the eyes which are wholly lacking in the latter, but this is not so of all other grasshoppers a number of which have these characters. It can be told in its first instar by a reference to the figure but after this stage the contrasting colours vanish and the insect becomes a rather dingy brown or black colour with obscure markings, these latter consist of a small white mark on the middle of the lateral lobes of the pronotum and a series of pale marks, one to a segment, on the sides of the abdomen. The hind femora are rather obscurely banded with two oblique, pale bars.

The adults can be identified by the tegmina, or outer wings, which are marked with large and small blackish spots, while the inner wings are almost transparent with only a faint indication of yellow. In this stage the species might be mistaken for *Encoptolophus costalis* Scud. but in the latter the tegmina are more solidly barred and the inner wings are outwardly blackish, the hind tibiae too, are blue instead of yellow.

The clear-winged grasshopper occurs in all the present agricultural parts of Canada. It breeds in grasslands and from these spreads to the cultivated crops where, at times, it does immense damage. Its eggs are deposited among the roots of clumps of grass, weeds, etc., or even around stones. They are of a pale cream colour with brown streaks and suffusions, those parts where they come in contact with another egg being palest; the surface is closely and deeply reticulated which gives it an appearance of being coarsely punctured. The egg-sac is at first small and the eggs within are closely packed, but as the embryos develop the eggs swell so that in spring time before hatching the sacs are often burst open or broken. The eggs at this time are clay yellow with brown streaks and shadings.

Melanoplus mexicanus Saus. (*atlanis* Riley), lesser migratory grasshopper.—This species can be recognized throughout its immature stages by the elongate orange or yellow mark near the middle of the lateral lobes of the pronotum. The first instar nymphs are usually dull black with pale marks and suffusions. In later stages they present a rather contrasting black and orange appearance. A reference to the figure will indicate the general pattern.

The nearest ally to this species is *M. bruneri* Scud. which it rather closely resembles; the latter, however, is usually darker and the pale areas are more broken up. The adults of *M. mexicanus* bear a close resemblance to several others and the females are hard to place. The males can be readily told by a reference to the subgenital plate the tip of which in this species is plainly notched, while the cerci are broad. In addition to these characters the males of this insect and of *bruneri* have a distinct protuberance between the middle legs not present in any other grasshopper. The only other species with a plainly showing notch at the anal extremity is *M. angustipennis* but in this insect the cerci are broadly spoon shaped, and there is no protuberance between the middle legs.

This species has now been fairly definitely associated with the destructive Rocky Mountain grasshopper, the latter being, it is believed, merely a long winged phase of *mexicanus*. Just what conditions bring about the change from normal to long wings is unknown although there seems little doubt that aridity is an important factor in the transformation. It is significant that the long winged forms are confined to the western half of the continent and that they do not occur in Eastern Canada. This seems to disprove the theory that crowded conditions are alone responsible for the change.

This insect was formerly known as *Melanoplus atlanis* Riley and the Rocky Mountain grasshopper *M. spretus* Walsh. It is present from the Atlantic to the Pacific.

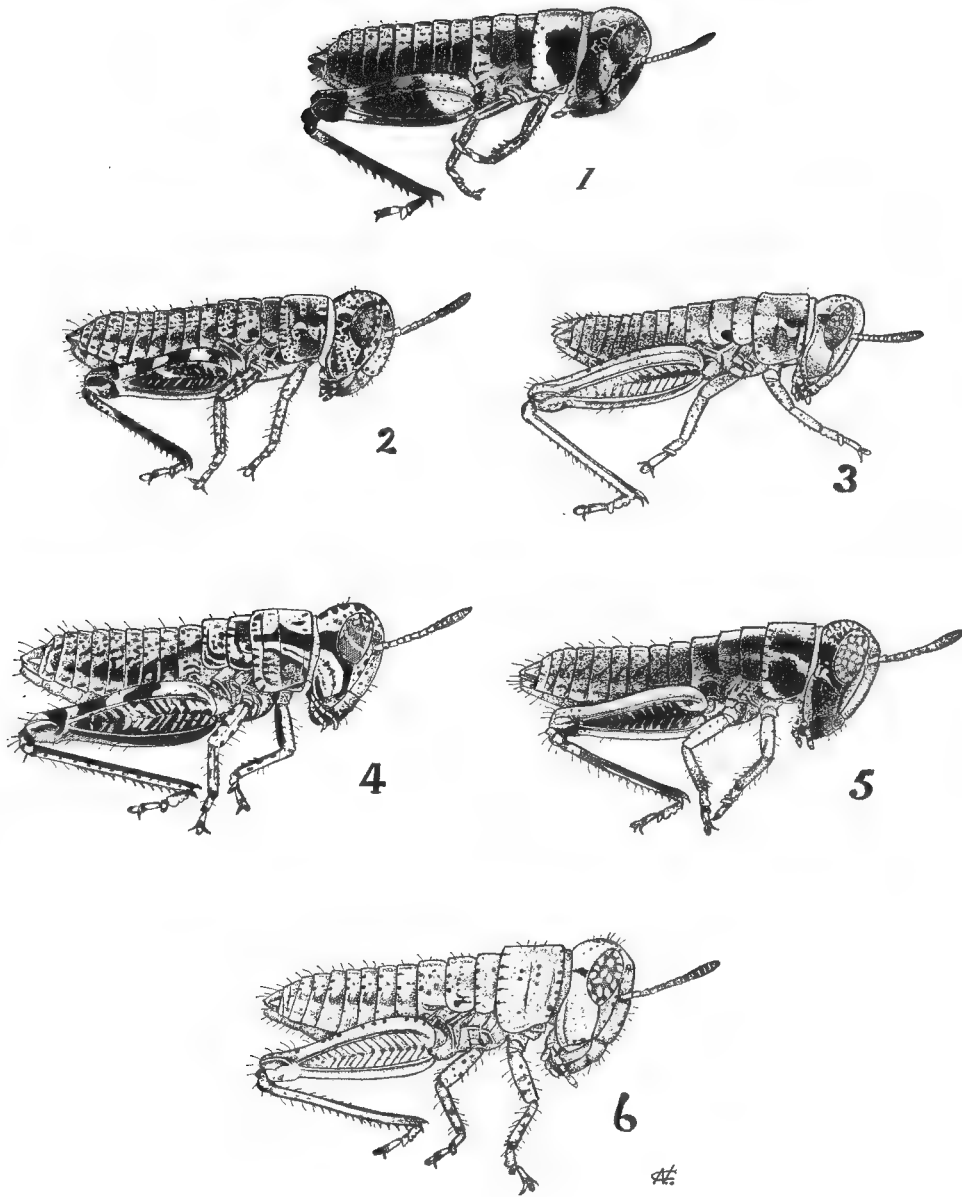


PLATE 1

- Fig. 1—First instar of *Camnula pellucida* Scud.
 Fig. 2—First instar of *Melanoplus mexicanus* Saus.
 Fig. 3—First instar of *Melanoplus bivittatus* Say.
 Fig. 4—First instar of *Melanoplus confusus* Scud.
 Fig. 5—First instar of *Melanoplus femur-rubrum* DeG.
 Fig. 6—First instar of *Melanoplus packardii* Scud.
 All much enlarged. (Original)

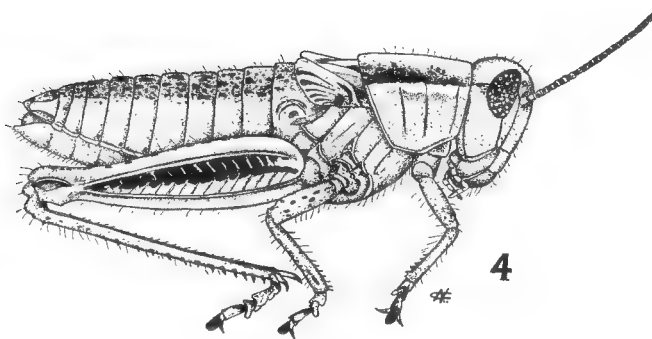
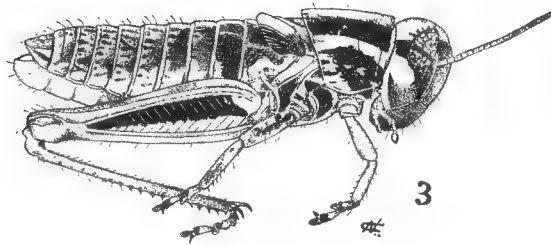
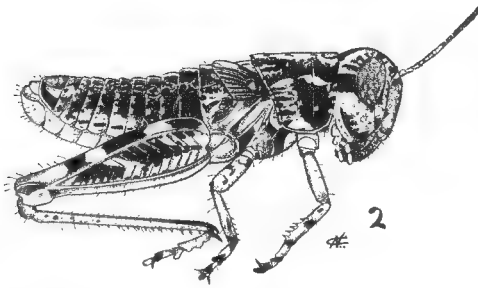
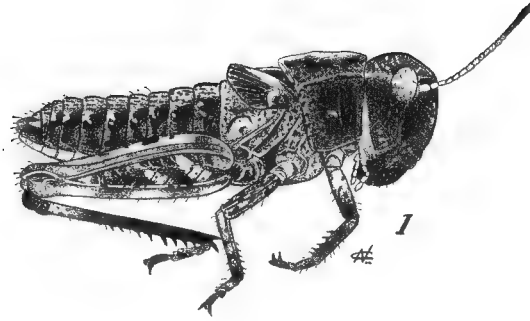


PLATE 2

- Fig. 1—Fourth instar of *Camnula pellucida* Scud.
 Fig. 2—Fourth instar of *Melanoplus mexicanus* Saus.
 Fig. 3—Fourth instar of *Melanoplus femur-rubrum* DeG.
 Fig. 4—Fourth instar of *Melanoplus bivittatus* Say.
 All enlarged. (Original)

Melanoplus bruneri Scud., Bruner's grasshopper.—The nymphs are very like those of *mexicanus* but average darker with the pale markings more broken up and restricted. The adults, also, resemble the latter species but are usually browner. The males can be recognized by the prolonged abdominal extremity.

This grasshopper is more restricted to semi-wooded, or shrubby areas than is *mexicanus* and it is more plentiful in northern districts such as the Peace River district. In such places it more or less supersedes the lesser migratory grasshopper and may become a pest of considerable magnitude.

Melanoplus femur-rubrum DeG., red-legged grasshopper.—This insect in the nymphal stage is rather strikingly coloured, the background being green or yellow and the black markings heavy. In the first instar the outer face of each hind femur is almost wholly black, in the later stages the black becomes restricted to the upper two-thirds. The insect is very like some of the darker forms of *bivittatus* although on an average the nymphs of the latter are much paler. It can be confused with no other species known to us.

Adults of this species on the other hand are like *mexicanus*. The males can be separated at once by the form of the sub-genital plate which is much more rounded or clubbed and has no terminal notch. The cerci taper apically and the protuberance between the middle legs is also lacking in *femur-rubrum*. The females are much more difficult to separate; they are greener or more slaty-grey on the sides, have less spotted tegmina and brighter yellow ventral surfaces. The hind femora, too, are never barred on the outer face although they may be suffused with black. The upper, outer flange is nearly always pale while in *mexicanus* it shows more or less distinct dark bars.

The red-legged grasshopper is one to two weeks later in appearing in spring than *mexicanus* and, also, later in maturing. It frequents lower and moister situations than the latter species and on that account is less widespread. It has never proved a serious pest in the Prairie Provinces but in Eastern Canada occasionally takes equal rank as a pest with the lesser migratory grasshopper.

Melanoplus bivittatus Say, two-striped grasshopper.—At first this insect is a small obscurely coloured hopper, usually of a dingy-brown colour. It later assumes a brighter dress and in its darker phases closely resembles *femur-rubrum*. As a rule it is of a cream or green colour with a few blackish marks and spots and always (except in the first instar) with the upper two-thirds of the outer face of the hind femora black.

The adults are among the largest of our clear-winged grasshoppers. The pale stripes along the sides of the pronotal disk extending along the tegmina, and the black striped legs, at once separate this grasshopper from others encountered in Canada.

The insect is primarily an inhabitant of low lands and weedy or shrubby areas. It has never been a serious pest in Canada although taking a yearly toll over a wide area. It lays a mass of from 40 to 108 eggs to a sac and two or more sacs in the course of a season. The eggs are dark orange-brown, semi-polished and widely but finely reticulated.

Melanoplus confusus Scud, minor grasshopper.—The early stages may be recognized by the use of the key and reference to the figure. The white curved line, or crescent, extending from the cheeks across the lateral lobes, separates it from *mexicanus* but not from several others of the less important grasshoppers. The adults, curiously enough, are the only ones of our species having pale tipped palpi. The hind tibiae are almost always blue.

This grasshopper is one of the first to hatch from eggs in the spring time and also the first to acquire wings. It has a limited habitat being usually restricted to the margins of woods or the vicinity of shrubs and tall herbage. It is not of very great economic importance and only occurs in Western Canada.

Melanoplus packardi Scud., Packard's grasshopper.—Immature insects of this species are often green or pale yellow, and in some of its forms it resembles *angustipennis* so closely that separation becomes a difficult problem. With an average specimen of the latter the markings are more pronounced and the hind femora distinctly barred, whereas in the former the femora are spotted.

Packard's grasshopper in its adult state is a large insect more apt to be confused with the two-striped grasshopper than with any other, the pale stripes on the pronotal disk are wide and distinct but they do not extend on to the tegmina, a fact which at once separates this species from *bivittatus*; moreover in our specimens the hind femora are without prominent markings, whereas in *bivittatus* they are black striped. In British Columbia, *packardi* may be much more heavily marked and the above description would not hold for these individuals. This insect is chiefly confined to the more sandy uplands of Western Canada and it is only in such places that it becomes of economic significance.

Melanoplus dawsoni Scud., Dawson's grasshopper.—This is a rather common grasshopper met with in semi-wooded districts. The first instar nymphs are unusually small and frail looking for the genus and their semi-transparent appearance combined with their black and orange coats gives them a combination of characters which is present in no other species. The adults are below average size and a majority have aborted wings.

This grasshopper is not of much importance to the average farmer and we have included it here because the unusual looking nymph is apt to attract attention and induce questions as to its identity. It is confined to the western part of the continent.

Dissostiera carolina L., Carolina grasshopper.—The first instar nymphs of this species are cream coloured with black and brown marks, the basal third of the hind femora being shiny black. We know of no features in the first stage hopper which enables us to distinguish it from several other genera such as *Spharagemon*, but with each succeeding moult it becomes more like an adult and so more easily recognized. The adults are among the largest of our grasshoppers and their black inner wings bordered with yellow provide an easy mark of identity.

The Carolina grasshopper is confined to bare spots, such as roadways, gardens and similar situations. At rest it is hard to see but when flying becomes a conspicuous object in the landscape. It has occasionally done considerable injury in gardens to seedling plants such as cabbage, radishes and turnips—but falls an easy victim to poisoned bait. It is widespread in Canada and common from Nova Scotia to Saskatchewan.

LIST OF PUBLICATIONS

The following publications of the Department of Agriculture relating to insects are available on application to the Director of Publicity, Department of Agriculture, Ottawa:—

The Control of the European Corn Borer.....	C.P.L.	No. 16
Tent Caterpillars.....	Circular	No. 1
Flea Beetles and Their Control.....	Circular	No. 2
The Chinch Bug in Ontario.....	Circular	No. 3
Common Garden Insects and Their Control.....	Circular	No. 9
The White-marked Tussock Moth and its Control.....	Circular	No. 11
The Control of Bark-beetle Outbreaks in British Columbia.....	Circular	No. 15
The Pear Thrips and its Control in British Columbia.....	Bulletin	No. 15
The Apple Bud-moths and Their Control in Nova Scotia.....	Bulletin	No. 16
The Fruit Worms of the Apple in Nova Scotia.....	Bulletin	No. 17

NEW SERIES

The Fruit Tree Leaf-roller and its Control in British Columbia.....	Circular	No. 10
How to Foretell Outbreaks of the Pale Western Cutworm in the Prairie Provinces	Circular	No. 12
The Beet Webworm.....	Circular	No. 14
The Control of Forest Tent Caterpillars in the Prairie Provinces.....	Circular	No. 19
The Apple Maggot and its Control in Quebec.....	Circular	No. 28
The Apple Curculio and its Control in Quebec.....	Circular	No. 36
Two Orchard Scale Insects, the San Jose Scale and the Oyster Shell Scale...	Circular	No. 37
The Blister Mite of Apple and Pear.....	Circular	No. 52
The Oriental Peach Moth in Ontario.....	Circular	No. 57
Mosquito Control in Canada.....	Circular	No. 62
The Round-headed Apple-tree Borer and its Control.....	Circular	No. 73
The Lecanium Scale.....	Circular	No. 77
The Strawberry Root Weevil.....	Pamphlet	No. 5
The Western Wheat-stem Sawfly and its Control.....	Pamphlet	No. 6
Directions for Collecting and Preserving Insects.....	Pamphlet	No. 14
Injurious Shade Tree Insects of the Canadian Prairies.....	Pamphlet	No. 47
The Control of the Destructive Spruce Bark Beetle in Eastern Canada....	Pamphlet	No. 48
Methods of Protection from Mosquitoes, Black Flies and Similar Pests of the Forest.....	Pamphlet	No. 55
The Pear Psylla and its Control.....	Pamphlet	No. 66
The Red-backed Cutworm and its Control in the Prairie Provinces.....	Pamphlet	No. 69
The Cabbage Flea-beetle and its Control in British Columbia.....	Pamphlet	No. 80
The Western Cedar Borer.....	Pamphlet	No. 94
The Army Cutworm.....	Pamphlet	No. 102
Insects of the Flower Garden and Their Control.....	Bulletin	No. 99
Household Insects and Their Control.....	Bulletin	No. 112

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